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(54) Title: ERROR DETECTION APPARATUS AND METHOD FOR ENGRAVERS

(57) Abstract

An error detection apparatus and method for use with engravers, such as gravure engravers. An error value E corresponding to the difference between a set of predetermined setup parameters and actual measurement of a portion of an engraved area on the cylinder (10) is determined. The error value E is then used to adjust the engraver to engrave an actual cut or etch in accordance with the set of predetermined setup parameters. Advantageously, an error detection and correction system is suitable for providing a closed-loop system for engraving a cylinder (10). The apparatus and method may be used during initial setup or during normal operation of the engraver.

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ERROR DETECTION APPARATUS AND METHOD FOR ENGRAVERS

Background Of The Invention

This invention relates to engraving heads of
the general type disclosed in Buechler U.S. Patent
4,450,486. Such engraving heads comprise a diamond
stylus carried by a holder mounted on an arm projecting
from a torsionally oscillated shaft. A sine wave driving
signal is applied to a pair of opposed electromagnets to
rotate the shaft through a maximum arc of approximately
0.25° at a frequency in the neighborhood of about 3,000
to 5,000 Hz.

A guide shoe is mounted on the engraving head
in a precisely known position relative to the oscillating
stylus. The engraving head is supported for tilting
movement by a set of leaf springs secured to a rearwardly
projecting bar. A DC motor rotates the bar so as to
bring the guide shoe into contact with a printing
cylinder to be engraved. When the guide shoe is in
contact with the printing cylinder, the stylus oscillates
from a position just barely touching the printing
cylinder to a retracted position about 100 microns
distant from the surface of the cylinder.

Once the guide shoe is in contact against the
printing cylinder a video signal is added to the sine
wave driving signal for urging the oscillating stylus
into contact with the printing cylinder thereby engraving
a series of controlled depth cells in the surface
thereof. The printing cylinder rotates in synchronism
with the oscillating movement of the stylus while a lead
screw arrangement produces axial movement of the
engraving head so that the engraving head comes into

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engraving contact with the entire printing surface of the printing cylinder.

In engraving systems of the type taught by Buechler, it is necessary for the machine operator to perform a tedious trial and error setup procedure at one end of the printing cylinder prior to commencement of engraving. This procedure involves adjustment of the gain on amplifiers for the sine wave driving signal and the video signal so as to produce "black" printing cells of a desired depth together with connecting channels of another desired depth and clean non-engraved white cells. Each change of one of the control variables interacts with the others, and therefore the setup becomes an iterative process.

It is therefore seen that a need has existed for an engraving system which may be quickly and easily set up to engrave cells of precisely controlled dimensions in the surface of a gravure printing cylinder.

Summary Of The Invention

In one aspect, this invention comprises a method for adjusting an engraver to engrave a cylinder with an actual cut according to predetermined setup parameters, said method comprising the steps of: (a) determining an error value corresponding to the difference between said predetermined setup parameters and an actual measurement of a portion of an engraved area on said cylinder; and (b) using said error value to adjust said engraver to engrave said actual cut in accordance with said predetermined setup parameters.

In another aspect, this invention comprises a method for measuring a portion of an engraved area on a cylinder in an engraver, said method comprising the step of generating a plurality of actual dimension values corresponding to said portion.

In still another aspect, this invention comprises a system for measuring a portion of an engraved

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area on a cylinder in an engraver, said system comprising a measuring device for generating a plurality of actual dimension values corresponding to said portion.

In yet another aspect, this invention comprises an error correction system for use in an engraver suitable for engraving a cylinder with an actual cut in accordance with predetermined setup parameters, said error correction system comprising determining means for determining an error value corresponding to the difference between the predetermined setup parameters and a measurement of the actual dimensions of a portion of an engraved area on said cylinder; and a system coupled to said determining means for receiving said error value and also for adjusting said engraver to engrave said actual cut in accordance with said predetermined setup parameters.

The present invention also provides an engraving apparatus and method wherein a plurality of parameter signals are supplied to a setup circuit for computing engraving parameters to control the engraving response of the engraving stylus to an input video signal. An input AC signal and an input video signal are applied to a multiplication circuit wherein they are multiplied by multiplication factors which are generated by a computer. The computer also generates a white offset signal which is combined with the output signals from the multiplication circuits to produce a driving signal for the engraving stylus. The stylus then engraves cells of the desired geometry.

The computer is provided with input signals which indicate a desired black cell width, a desired channel width, a desired highlight cell width and the video voltage level at which a highlight cell of the desired width is to be engraved. The values of these parameters are used for solving a set of equations which produce the appropriate values for the two multiplication factors and the white offset.

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A video camera is operated to produce a frame
of video information including an image of a highlight
which has been engraved by a video signal of a
predetermined level. A video processing circuit measures
the width of the cell which has been so imaged and
reports it to the computer. The computer then adjusts
the multiplication factors and the white offset through
use of an error term which is equal to the difference
between the expected cell width and the measured cell
width.

Brief Description Of The Drawings

Fig. 1 is a schematic illustration, partly in
perspective, of a programmable engraving system according
to the present invention;

Fig. 2 is a schematic illustration of a series
of cells engraved in a printing cylinder;

Fig. 3 is a schematic illustration of AC and
video signals for controlling an engraving stylus and the
engraving movement which results therefrom;

Fig. 4 is a flow chart illustrating the method
of cell width control in accordance with the invention;

Fig. 5 is a graphical plot of the maximum cell
depths resulting from video input signals ranging from 0
to 10 volts;

Fig. 6 is a schematic illustration of a video
frame including a highlight cell;

Fig. 7 is a flow chart of a cell width
measuring algorithm; and

Figs. 8A and 8B, taken together, show a flow
chart of another measuring algorithm.

Description Of The Preferred Embodiment

Referring to Fig. 1 there is illustrated a
gravure printing cylinder 10 mounted for rotation by a
drive motor 12 and engraving by an engraving stylus 20.
During the engraving operation, stylus 20 moves

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engravingly toward and away from printing cylinder 10 to
produce a series of cells arranged along a track 30.   A
lead screw motor 14 rotates a leadscrew 56 to cause
movement of stylus 20 in a direction parallel to the axis

5   of cylinder 10.   If lead screw motor 14 moves
continuously, then track 30 will have a helical
configuration.   Intermittent energization of motor 14
produces a series of spaced circular tracks 30.

Stylus 20 is driven into engraving contact with

10   print cylinder 10 by an electromagnetic driver 16
operating in response to a drive control signal on line
60.   Electromagnetic driver 16 may be configured as
generally disclosed in Buechler U.S. Patent 4,450,486.

The signal on line 60 has an AC component, a

15   video component and a white offset component appropriate
for producing an engraving action as hereinafter
described.   The AC component is derived from an AC input
signal which is applied to a multiplier 36 and multiplied
by a multiplication factor Ka obtained on a line 71 from

20   a computer 34.   The AC product signal from multiplier 36
is applied to a summing junction 40 where it is combined
with a signal from another summing junction 26.   Summing
junction 26 combines an offset signal WD on line 72 from
computer 34 with an output signal from a second

25   multiplier 38.   The function of multiplier 38 is to
multiply an input video signal by a factor Kd generated
by computer 34 on line 73.

Computer 34 generates the parameters Ka, Kd and
WD by solving a set of three equations as described

30   below.   A control panel 38 is provided in order enable
entry of values for five constants appearing in the three
equations.   These constants are black cell width, BW,
highlight cell width, HW, the video voltage, Vh,
corresponding to HW, HW, a stylus constant, Ks, and the

35   black cell voltage, Vmax.   A shoe offset, S, may also be
entered if desired.

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As hereinafter discussed in more detail, the AC component of the signal on line 60 causes stylus 20 to oscillate in a sinusoidal manner relative to printing cylinder 10 with a wavelength dependent upon the surface speed of the cylinder. The rotational speed of drive motor 12 must be adjusted so as to produce an engraving track 30 having an odd number of half wavelengths during a full engraving rotation. Computer 34 transmits a lead screw control signal to lead screw motor 14 via a line 24. This signal is adjusted so as to cause lead screw motor 14 to advance stylus 20 an axial distance equal to one-half of a black cell width plus one-half of a connecting channel width, plus one separating wall width during each complete rotation of the printing cylinder 10.

The equations for Ka, Kd and WD assume a linear relationship between the input video signal and a resultant engraved cell width. While this is a fairly accurate assumption in many cases, there are times when adjustments are required. If so, then tabulated corrections may be made as taught in Serial No. 08/022,127, the parent application hereof, the disclosure of which is incorporated herein by reference.

Another problem is drift. Although computer 34 may be programmed properly and may initially produce correct cell widths, gain changes in analog components or mechanical changes in the positioning of the shoe which supports stylus 20 may require incorporation of an adjustable correction term in the algorithm employed for calculation of Ka, Kd and WD. For this purpose there is a video camera 46 which is focussed on track 30. Camera 46 views a portion of track 30 which is illuminated by a strobed lamp 58 and provides frames of video feedback information to a video processor 41. Strobe signals for lamp 58 are provided at the correct frequency and phase by a cell counter 42 on line 55.

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Although not shown, in the embodiment of the
invention, the strobed lamp 58 is integral with the video
camera 46 so that the strobe flashes through a lens (not
shown) of video camera 46. In addition, the video camera
5   46 is an autofocus camera which can focus on any size
print cylinder 10. The video processor 41 is capable of
controlling the autofocus feature so that if, for
example, the printing cylinder 10 is changed to a
printing cylinder having a different radius. The video
10   processor 41 includes conventional circuitry to ensure
that the image is in focus. Cell counter 42 counts
pulses generated by a clock 47 at four times the AC
frequency. At this frequency a clock pulse is generated
each quarter wavelength of engraving stylus oscillation.
15   The geometrical configurations of typical black
cells, connecting channels for black cells, highlight
cells and separating walls are illustrated in Fig. 2.
That figure depicts a series of wide, deep black cells 70
and a series of shallower and narrower highlight cells
20   76. The illustrated cells comprise portions of three
side-by-side engraving tracks 30. Black cells 70 have a
maximum width BW. The control signal for the stylus is
adjusted so as to produce connecting channels 72 between
successively engraved black cells 70. Channels 72 have a
25   width CW, while highlight cells 76 have a width HW. The
scalloped edges of the cells 70 result from the
vertically oscillating cutting action of stylus 20 during
rotational movement of printing cylinder 10 thereunder.
As further illustrated in Fig. 2, a series of
30   successively engraved black cells 70 may be separated by
a wall 74 from a series of successively engraved cells 70
(also illustrated as being black cells) in an adjacent
engraving track 30.
A series of cells configured as illustrated in
35   Fig. 2 will print a graphic pattern defining a diagonally
extending screen. The tangent of the screen angle is the
ratio of the black cell width to the wavelength of the

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stylus cutting motion. The cutting wavelength is a
function of the surface speed of the printing cylinder 10
and the oscillation frequency of stylus 20. Thus, the
screen angle may be adjusted by adjusting the rotational
5   speed of drive motor 12, but such adjustment must be made
in incremental steps so as to maintain an odd number of
half wavelengths around the circumference of the printing
cylinder. Alternatively, the screen angle may be
adjusted by adjusting the black cell width and the
10   operating speed of leadscrew motor 14.

The driving signals for stylus 20 and the
resulting vertical movement of the stylus 20 are
illustrated in Fig. 3. The driving signal is obtained by
adding an AC signal 80 to a video signal 82. The
15   illustrated video signal 82 has, by way of example, a
white video level 86, a black video level 88 and a
highlight video level 90. The video signal and the AC
signal are combined with an offset such that the stylus
is raised out of contact with the cylinder surface during
20   the entire time that video signal 82 has a white level
86. The minimum white elevation is WD.

When video signal 82 goes from a white level to
a black level, stylus 20 moves into engraving contact
with the cylinder as shown by stylus position line 84.
25   In this condition the stylus oscillates between a minimum
depth CD and a maximum depth BD. When stylus 20 is at
the depth CD, it engraves a connecting channel 72. When
video signal 82 shifts to a highlight level as indicated
by the reference numeral 90, stylus 20 oscillates between
30   a position out of engraving contact with cylinder 10 to
an engraving position having a maximum depth HD. AC
signal 80, video signal 82 and a white offset signal are
produced by setup circuit 34.

In general, a set of predetermined setup
35   parameters (BW, HW, Vh, Ks and Vmax) may be inputted into
control panel 32. These predetermined setup parameters
generally correspond to the desired dimensions of, for

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example, either the highlight cell 76 or cell 70. These
parameters are received by computer 34 which, in turn,
generates a plurality of energizing signals (Ka, WD and
Kd) in response thereto. The input signals control the

5   depth of stylus 20 at any instant in time. In the
embodiment being described, the computer 34 determines
the depth of stylus 20 by using the following equations.

$$D(t) = Ka * A * (\sin(\omega * t) - 1) - WD + Kd * V(t)$$

10   where:

Ka = gain factor of the AC amplifier
A = maximum value of the AC reference signal
ω = frequency of AC reference signal
t = time

15   WD = white offset
Kd = gain factor of video amplifier
V(t) = video voltage at input (function of
time)

The maximum black depth occurs when $\sin(\omega * t) = 1$ and

20   v(t) = Vmax. Therefore the black depth is given by:

(1) BD = Kv * Vmax - WD

The channel depth CD occurs when $\sin(\omega * t) = 0$ and
v(t) = Vmax. Therefore the channel depth is given by:

(2) CD = Ka * A - WD + Kv * Vmax

25   The highlight depth HD occurs when $\sin(\omega * t) = 1$ and
v(t) = highlight voltage Vh. Therefore :
(3) HD = Kv * Vh - WD
For an engraving operation using a stylus having a
cutting tip angle (tip), the depths BD, CD and HD are

respectively equal to Ks * BW, Ks * CW and Ks * HW, where
Ks is a stylus constant given by the equation:

$$Ks = 1 / (2 * TAN(tip / 2)).$$

5   Making the above indicated substitution, equations (1) -
       (3) can be rearranged to produce:

       (4)   Kv = Ks * (BW - HW + E) / (Vmax - Vh)
       (5)   WD = Kv * Vmax - Ks * BW
       (6)   Ka = (Ks * CW + WD - Kv * Vmax) / A

       where E is an error which is used to correct the solution
10   for observed errors in HW.
              Equations (4) - (6) may be solved in sequence.
       Thus the value of Kv obtained from the solution of
       Equation (4) may be used in the solutions of Equations
       (5) and (6), and the value of WD obtained from Equation
15   (5) may be used in Equation (6). Computer 34 proceeds in
       this fashion to calculate Kv, WD and Ka. Alternatively,
       the screen angle (SA) and the wavelength (WL) of the
       stylus cutting motion may be used as setup parameters.
       In that case BW may calculated from the equation:

20   BW = WL * tan(SA)

       This value of BW then is used in the computation of the
       engraving parameters.
              In the event that there is a small error in the
       positioning of the shoe against printing cylinder 10,
25   then an additional predetermined setup parameter S may be
       supplied to computer 34. If this parameter is provided,
       it is treated as a depth offset which is multiplied by Ks
       and added to BW, CW and HW prior to performing the above
       outlined solution.
30   Referring now to Fig. 5, the maximum cell depth
       is seen to be directly proportional to the video input

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signal. As illustrated in the figure, a maximum 10 volt
video input signal produces the maximum cell depth BD
required for engraving a black cell. For the illustrated
example, computer 34 has been given a highlight width HW

5   = .25 * BW. Hence the highlight depth HD is 25% of BD.
The Figure also reflects a setting of 3 volts for Kh.
Under those conditions a video signal having an amplitude
equal to 30% of a "black" video signal produces a cut
having a depth which is only 25% of the black cell depth.

10   As a result the maximum cell depth goes to zero for a
video input of about 0.7 volts. For video signals
smaller than that amount, the cutting stylus remains out
of contact with the printing cylinder. For a "white"
video input the stylus is retracted from the engraving

15   cylinder by a minimum distance WD, which is the white
offset.

        During the initial setup of the print cylinder
10 for engraving or even after engraving has begun, it
may be desirable to adjust the predetermined setup

20   parameters BW, HW, Vh, Ks, and Vmax and their associated
energizing signals Kd, WD and Ka to reflect differences
between the predetermined setup parameters and an actual
measurement of a portion of an engraved area (Fig. 2).
This facilitates providing a closed-looped system which

25   can be self-adjusting and self-monitoring. In order to
effect this closed-looped system, it is necessary to
calculate an error value which generally corresponds to
difference between the predetermined setup parameters and
an actual measurement of the portion of the engraved area

30   on the print cylinder. Once the error value is
determined, the computer 34 can adjust the predetermined
setup parameters and corresponding energizing signals Ka,
WD and Kd in response to the error value E.

        It is important that camera 46 may be adjusted

35   for viewing a precisely determined position of track 30.
It is to be noted that an individual cell is strobed
while the engraver is engraving. For this purpose,

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stylus 20 is activated to engrave a test track at one end
of cylinder 10. Although it is possible that an operator
could view a monitor or display (not shown) and
manipulate a cursor control knob (not shown) on the
5   above-mentioned keyboard, computer 34 is capable of
automatically strobing a flash and capturing an image on
the video camera 46. The video processor gets the new
image and measures the width of the strobed cell and its
associated channel. This information is sent to computer
10   34 as cell size feedback information. Since there is a
distance between the stylus 20 and the camera pickup 46,
computer 34 has to save a cell position distance count
between camera 46 and stylus 20. The computer uses this
position offset count to time strobes on line 55 for
15   imaging specific cells known to have been engraved at
particular points in time.

Fig. 4 illustrates the overall process involved
in controlled engraving and error correction system
according to one embodiment of the present invention.
20   The process begins at an entry point indicated by the
reference numeral 100. The first step is the entry of
the setup parameters BW, HW, Vmax, Vh and Ks (Block 102).
These parameters may be read from a disk file or entered
into a keyboard by an operator. In the case of operator
25   entry, the predetermined setup parameters may be obtained
by visual observation of cells in a manually controlled
sample track which is cut at one end of printing cylinder
10. However entered, the predetermined setup parameters
are stored in computer 34 for setup control. Computer 34
30   then sets the value of the error term, E, equal to a zero
(Block 104) and proceeds to calculate the engraving drive
parameters Kd, WD and Ka using equations (4) - (6) above
(Block 106). This puts the system in readiness to
commence engraving.

35   Once the engraving drive parameters are
available, computer 34 generates the energizing or
control signals which cause video data to be read pixel

data from an appropriate data file (Block 108). Other
control signals activate drive motor 12, leadscrew motor
14 and workhead 16, and engraving begins (Block 110).
Computer 34 then begins checking the progress of the
5   engraving job (Point 112). The system exits at Point 114
when the job is done.

In one embodiment, the error value E may be
determined by using one predetermined setup parameter,
namely, Vh. In general, the error correction system
10   calculates error value E by comparing the most frequently
occurring value of Vh for a plurality of cells that have
actually been cut to a value of Vh which is determined by
taking an actual measurement of a preselected cell 606
(Fig. 7) which has been cut. A most frequently occurring
15   value of Vh is assumed to be the system setup parameter
or the predetermined setup parameters. Therefore
computer 34 maintains a record of the frequency of
occurrence of different values of Vh (Block 116) and
compares the set value of Vh against the value of Vh
20   which is found to be most frequently occurring. When the
set value is found to deviate more than a prescribed
minimum amount from the most frequently occurring value,
then the predetermined setup parameters and corresponding
energizing signals are adjusted. In the embodiment being
25   described, a corresponding new value of HW may be
calculated. This calculation involves solution of the
equation:

$$HW = (Kd * Vh - WD) / Ks.$$

As the engraving proceeds, periodic checks are
30   made to ascertain whether the system is engraving
highlight cells of width HW in response to video input
signals of voltage Vh. When a measurement time arrives,
as indicated by the check at Point 122, the system
proceeds to Block 124. This block involves a strobing of
35   lamp 58 which causes camera 46 to generate a frame of
video information. Video processor 41 is also strobed to
measure the width of a highlight cell which appears in

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the video frame and which is known to have been engraved
in response to a video voltage Vh. The error term, E, is
set equal to the difference between the actual measured
value HW and the current setting of HW. The system then
5   proceeds back to Block 127 where the predetermined setup
parameters, such as Kd, WD and Ka, are recalculated in
computer 34 using the new value of E. This has the
effect of eliminating or reducing the error value E. The
system then returns to block 108.

10   Video camera 46 is mounted on a frame 57
supported by leadscrew 56. Camera 46 is adjustable
relative to frame 57 so as to generate frames of video
information which are centered upon track 30.
Preferably, camera 46 comprises a CCD array which produce
15   a new frame of video information with each flash of lamp
58.

It is important that camera 46 be adjusted for
viewing a precisely determined portion of track 30. For
this purpose stylus 20 is activated to engrave a test
20   track at one end of cylinder 10. Computer 34 saves this
position count and uses it to time the strobes on line 55
for imaging specific cells known to have been engraved at
particular points in time.

Fig. 6 illustrates a typical frame of video
25   information 600 including a highlighted cell 606 which
was engraved PC clock counts prior generation of the
strobe which produced the frame 600. Frame 600 comprises
a series of horizontal lines which are too numerous for
illustration. Representative horizontal video lines are
30   indicated by the reference numerals 602. These lines are
a subsampling of the cell image captured by the strobe.
The actual cell size dimensions are measured from these
lines.

Video processor 41 processes lines 602
35   sequentially from top to bottom. The video information
goes through localized thresholding (not shown). Pixels
which are lighter than the threshold are deemed to be

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white, whereas pixels which are darker than the threshold
are deemed to be black. In the embodiment being
described, the threshold amounts are set at a preselected
gray scale.

5   As each line of video information is processed
by thresholding, it is examined for the presence of
black/white and white/black transitions. Fig. 6
illustrates black/white transitions by symbols denoted by
the reference numeral 610, whereas white/black
10   transitions are denoted by symbols indicated by the
reference numeral 611. This establishes a series of
boundary lines as illustrated in Fig. 6 by reference
numerals 604, 605, 606, 607, 608 and 609. These boundary
lines define a white region 650.

15   Video processor 41 recognizes the white region
650 by a black/white transition 610 followed by a
white/black transition 611. For each such transition
pair, video processor 41 establishes a first linked list.
If the programming is performed in the C language, for
20   example, then such a linked list may be represented by an
entity known as a structure. Each such linked list
includes the X coordinates of the left and right
boundaries of the white region indicated by the
transition pair. The linked lists for each scan line 602
25   are associated with the linked lists of the preceding
scan line by comparison of the boundary points.

For the first six video lines 602 of Fig. 6,
only one white span (and one linked list) appears.
However, on the seventh horizontal line, denoted by the
30   reference numeral 602a, two additional transition points
611d, 610d appear. These two new transition points mark
the boundaries of highlight cell 60. It can be seen that
the appearance of highlight cell 60 causes a "split" in
the white region 650. Video processor 41 reacts to this
35   split by establishing a second and third linked lists to
replace the first linked list previously being processed.

Once a split is observed, the video processor
knows that highlight cell 606 is present The video
processor then compares the left boundary of the third
linked list with the right boundary of the second linked
5   list to determine the width of the highlight cell 606.
The highlight width is calculated for each scan line 602
and compared with the highlight width calculated for the
preceding scan line. Each time a comparison is made,
video processor 41 saves the larger value. The process
10   continues until the intermediate black region disappears
(at 602b) and the two legs of white region 650 merge. At
this point the measurement ceases and the processor saves
the observed maximum value of HW. Video processor 41
passes this value of HW to computer 34. The computer 34
15   associates the reported value of HW with the specific
engraving command, which was sent to stylus 20 PC clock
counts earlier than the strobe which produced the video
frame. For this purpose computer 34 samples the video
information which is supplied to multiplier 38.

20   Fig. 7 illustrates the above outlined measuring
process in flow chart form. Thus, HW measurement begins
at a start point 136 and proceeds to a scanning step at
block 138. As discussed above, frame grabbing or
scanning is initiated by a strobe signal on line 55. It
25   should be appreciated that the cylinder could be
stationary (i.e., not revolving during) the videoing,
measuring and error correction process. It should also
be noted that the system and method for measuring may be
used independently to provide means for measuring
30   portions of actual cuts in cylinder 10. Thus, the system
and method of measuring per se could be used to measure
the actual measurements for display on a monitor (not
shown) so that subsequent manual adjustments, for
example, can be made to correct for any errors.

35   Once a frame has been scanned the video
processor checks the line number at point 140. If the
bottom of the frame has been reached, then there is an

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exit at point 142. Assuming that the frame bottom has
not been reached, the program proceeds to block 144 where
it establishes transition points 610, 611. Then the
program obtains the white ranges at block 146 for use in
the above-described linked lists. Next the program looks
for a split at point 148. If a split is noted, then the
two resulting linked lists are tagged at block 152 and a
flag is set at block 154.

The program checks the state of the flag at
point 156 and jumps down to block 164 for a negative
result. This means that the top of highlight cell 606
has not yet been reached and there is no need to measure
a cell width. Consequently, the program simply
increments the line number at block 164 and returns back
to point 140.

If the check at point 156 indicates that the
flag has been set, then the program checks for a merge at
point 158. If a merge is noted, then the program exits
from the measurement routine. If a merge has not yet
occurred, then the program checks the separation distance
between the two legs of the white region 650. This
distance is compared at point 160 against previously
saved separation distances. If the new separation
distance is greater than any previously saved distance,
then HW is set equal to that distance. Referring again
to Fig. 6, the first separation distance is the distance
between points 611d and 610d. This distance keeps
increasing until the program reaches points 611a and
610a. At that point the separation distance is maximum,
and no further adjustments of HW are made.

The video processor 41 then feeds the measured
value of HW back to computer 34 and it is compared to the
most frequently occurring value of HW. If the difference
is below a predetermined threshold or zero, then no
adjustment is made to the predetermined setup parameters.
If on the other hand, there is a difference between the
HW measured and the most frequently occurring value of

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HW, then computer 34 adjusts the predetermined setup
parameters until the engraver is cutting cells that fall
within the predetermined setup.

5   Thus, in the embodiment being described, this
invention comprises a method for measuring a portion 67
(Fig. 2) of an engraved area 69 on the cylinder 10 during
rotation of the cylinder 10 or while the cylinder 10 is
stationary.   The method uses video processor 41,
videocamera 46 and strobe 58.   The method comprises the
10   steps of videoing the portion 67 of the engraved area 69
and generating a video image (such as the image shown in
Fig. 6) corresponding thereto.   These steps are effected
by using the video processor 41 to process the video
image data in order to determine the actual measurements
15   of the portion which was videoed.

Fig. 8 shows another embodiment of the
invention wherein the cell width BW, channel width CW,
highlight width HW, and error value E are measured and
determined using a similar technique.   In this
20   embodiment, video processor 41 determines the existence
of the white region 650 by the black/white transition 610
followed by a white/black transition 611.   The cell which
was actually measured and strobed is assumed to be
generally located in the center of the scan frame 600.

25   At this point, the video processor 41 begins a
filling in process whereby it starts from a location
somewhere within cell 606 and begins filling in memory
locations associated or corresponding to cell 606 with
gray scale values.   Video processor first selects a black
30   pixel, which is preferably centrally located within cell
606.   Video processor 41 then "fills" the selected pixel
and all adjacent black pixels with a half tone or gray
value which is somewhere between the white and black
values which are conventionally stored in memory.

35   This fill-in process continues until all pixels
within cell 606 are filled with a half tone value.   It is
to be noted that if the half tone value reaches either a

top 621 (Fig. 6) or bottom 623 of scan frame 600, the
video processor has determined that it is measuring
boundaries for cell 70 (Fig. 2) and channel 72.   On the
other hand, if the filled in pixels do not reach the top

5   621 or bottom 623 of scan frame 600, then video processor
41 regards the cell being measured as a highlight cell 76
(Fig. 2).   If the half tones reach sides 625 and 627 of
the screen, then video processor 41 determines that no
cell is being measured.

10   For purposes of illustration, it will be
assumed, as it was above, that video processor 41 is
measuring a highlight cell 70 (Fig. 2) and 606 (Fig. 6)
which was strobed by video camera 46 and strobed lamp 58.
As video processor 41 completes filling in cell 606, it

15   conventionally stores all black/white transition points
and white/black transition points in memory.

             After video processor 41 has completed filling
in cell 600, the black/white and white/black transition
points are located.   These transition points generally

20   correspond to the boundary lines or wall 606 (Fig. 6).
The video processor 41 then examines these transition
points and determines, by each horizontal scan line 602,
the leftmost and rightmost (as viewed in Fig. 6)
transition points.   These transition points correspond to

25   the points, like points 615 and 617 around the boundary
of cell 606.

             After all the boundary transition points have
been determined, the maximum and minimum distances
between transition points which lie on the same

30   horizontal scan line 602 are determined.   These values
are conventionally subtracted by video processor 41,
thereby resulting in values associated with the distance
between the walls of highlight cell 606.   Video processor
41 then scales these values to the pixel sizes of video

35   camera 46 (Fig. 1).

             In the illustration being described, and as
viewed in Fig. 6, the largest difference between

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black/white and white/black transitions is at points 610a
and 611a. The distance between these two points 610a and
611a represents the maximum separation distance, and
consequently, the highlight width, HW. Video processor
5   41 determines that this is a highlight cell because no
half tones reached the top 621 or bottom 623 of the scan
frame 600.

It is to be noted that the channel width, CW,
of channel 72 (Fig. 2) and cell width, BW, of cell 70 are
10   determined in a similar manner by video processor 41.
For example, the minimum distance determined by video
processor 41 would correspond to the channel width, CW.
If the video processor 41 determines that the minimum
distance is below zero, then there is no channel and it
15   is assumed a highlight cell, like cell 606 in Fig. 6, is
being measured. As with the maximum distance, the
minimum distance between black/white and white/black
transitions which lie on the same line 602 are scaled to
the magnification and pixel sizes of video camera 46
20   (Fig. 1).

Referring back to the illustration being
described, once the highlight width, HW, has been
measured, it is fed back to computer 34 and the error
value E is determined. Computer 34 receives the
25   highlight width HW and compares it to the HW
corresponding to the predetermined set up parameters. If
the error value E is below the predetermined threshold or
zero, then no error adjustment is made to the
predetermined setup parameters because the engraver is
30   engraving highlight cells 76 (Fig. 2) having actual
measurements which generally correspond to desired
measurements prescribed by the predetermined setup
parameters.

On the other hand, if the error value E is
35   above the predetermined threshold, then an error
adjustment is made. In this regard, computer 34
determines that the highlight cell 76 (Fig. 2) actually

being engraved has dimensions which are different from
the dimensions corresponding to the predetermined setup
parameters. As mentioned earlier herein, computer 34 may
use the most frequently occurring value of HW to

5   determine the error value E. In this case, the error
value E would represent the difference between the HW and
the most frequently occurring value of HW which has been
stored in memory for a plurality of highlight cells 76
which have been strobed and measured.

10   In the embodiment being described, computer 34
causes several measurements of the same size highlight
cell 76 to be taken to verify the error value E.
Computer 34 then adjusts one or more of the predetermined
setup parameters BW, HW, Vh, Ks, Vmax and S to account

15   for the error value E.
           Fig. 8 illustrates the measuring process
according to this embodiment of the invention. The
measuring process begins at start block 170 and proceeds
to scan a frame of data at block 172. This is similar to

20   the measuring process described above with respect to
Fig. 7. After the scan frame of data is captured, the
data is broken down into a plurality of localized sectors
at block 174. Using a plurality of smaller localized
sectors in this embodiment of the invention permits the

25   video processor 41 and computer 34 to process data
faster. Threshold points are determined for each
localized sector. Thresholding is performed with each
sector so that white/black and black/white transition
points within that sector can be located. This process

30   continues until all the black/white and white/black
transition points are found for each sector in the scan
frame and, ultimately, for the entire cell being measured
at block 176. The video processor 41 begins the memory
fill at block 180 by filling in all the black cavities

35   for the cell being measured. Thereafter, the maximum and
minimum transition points on a particular scan line are
identified by video processor 41 at block 182.

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    At point 184, the video processor 41 checks to
determine if the memory fill in has reached the sides 625
and 627 (Fig. 6). If it has reached sides 625 and 627,
then video processor 41 determines that no cell or
5   channel is being measured (block 186). If it has not
reached sides 625 and 627, then video processor 41
determines if the fill in has reached top 621 or bottom
623 at point 188. If the top 621 or bottom 623 has been
reached, video processor 41 calculates the channel width
10   CW and cell width BW at block 190 using the maximum and
minimum values determined at block 186. If the top 621
or bottom 623 has not been reached, then video processor
determines the highlight cell width HW at block 192.
After all the measurements have been determined, video
15   processor exits at point 194, whereupon an error value E
is determined by computer 34 in the manner described
earlier herein.

    Advantageously, this invention provides an
error detection and correction system suitable for
20   providing a closed-loop system for engraving highlight
cells 76 (Fig. 2), cells 70 and channels 72 in a gravure
engraver. The error detection and correction system
permit an error value E to be determined and fed back to
computer 34, whereupon feedback adjustments can be made
25   to one or more of the predetermined setup parameters.
This permits the gravure engraver to engrave actual cuts,
cells and channels in accordance with predetermined setup
parameters.

    It is to be noted that this system may be used
30   during initial setup or during the normal operation of
the gravure engraver. Thus, the system and method
described herein can provide "real time" display of the
actual measurement and "real time" correction for any
error value E.

35   While the method herein described, and the form
of apparatus for carrying this method into effect,
constitute preferred embodiments of this invention, it is

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to be understood that the invention is not limited to
this precise method and form of apparatus, and that
changes may be made in either without departing from the
scope of the invention, which is defined in the appended

5   claims.

What is claimed is:

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1.   A method for measuring a portion of an engraved area on a cylinder in an engraver, said method comprising the step of:

    (a) generating at least one actual dimension values corresponding to said portion.

2.   The method as recited in claim 1 wherein said method further comprises the step of:

    (b) displaying said portion and said at least one actual dimension values on a monitor.

3.   The method as recited in claim 1 wherein said step (a) further comprises the steps of:

    (a)(1) videoing said portion of said engraved area and generating a video image corresponding thereto;

    (a)(2) generating said at least one actual dimension values using said video image in step (a)(1).

4.   The method as recited in claim 1 wherein said step (a)(1) further comprises the step of:

    (a)(1)(i) measuring said portion of said engraved area during real time operation of said engraver.

5.   The method as recited in claim 3 wherein said step (a)(1) is effected by using a video camera and said step (a)(2) is effected by using a video processor which is coupled to the video camera.

6.   The method as recited in claim 5 wherein said engraver is a gravure engraver and said portion is a cell which has actually been cut into said cylinder.

7.   The method as recited in claim 4 wherein said step (a)(1)(i) further comprises the step of:

    displaying said at least one actual dimension values during said real time operation.

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8.   The method as recited in claim 1 wherein said step (a)(1) further comprises the step of:
              (a)(1)(i) measuring said portion of said engraved area while the cylinder is stationary.

9.   The method as recited in claim 8 wherein said step (a)(1)(i) further comprises the step of:
              displaying said at least one actual dimension values while said cylinder is stationary.

10.   A system for measuring a portion of an engraved area on a cylinder in an engraver, said system comprising:
              a measuring device for generating a plurality of actual dimension values corresponding to said portion.

11.   The system as recited in claim 10 wherein said measuring device further comprises:
              a video camera for taking a video of said portion;
              a video processor coupled to said video camera for generating said plurality of actual dimension values in response to said video.

12.   The system as recited in claim 11 wherein said measuring device further comprises:
              a strobe associated with said video camera for strobing said portion.

13.   The system as recited in claim 12 wherein said strobe is integral with said video camera.

14.   A method for adjusting an engraver to engrave a cylinder with an actual cut according to predetermined setup parameters, said method comprising the steps of:

(a) determining an error value corresponding to the difference between said predetermined setup parameters and an actual measurement of a portion of an engraved area on said cylinder; and

(b) using said error value to adjust said engraver to engrave said actual cut in accordance with said predetermined setup parameters.

15.   The method as recited in claim 14 wherein said step (a) comprises the steps of:

(a)(i)   electronically measuring the actual dimensions of said portion of said engraved area;

(a)(ii)   comparing said actual measurement to said predetermined setup parameters.

16.   The method as recited in claim 15 wherein said step (a)(i) comprises the steps of:

(a)(i)(1)   strobing said portion of said engraved area and generating a frame of data corresponding thereto;

(a)(i)(2)   determining a plurality of transition points corresponding to black/white and white/black transitions within said scan frame of data;

(a)(i)(3)   using said transition points to calculate a maximum distance value and a minimum distance value for a cell located within said engraved area.

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17.   The method as recited in claim 14 wherein said
engraver comprises a computer capable of receiving a
plurality of input signals corresponding to said
predetermined setup parameters and generating a plurality
5   of energizing signals in response thereto, said step (b)
further comprising the steps of:
          (b)(1)   using said error value to modify said
energizing signals so that said engraver engraves an
actual cut which generally corresponds to said
10   predetermined setup parameters.

18.   The method as recited in claim 14 wherein said
step (a) is effected by using a processor and a video
strobe coupled to said processor.

.19.   The method as recited in claim 18 wherein said
video strobe comprises an automatic focusing system.

20.   An error correction system for use in an
engraver suitable for engraving a cylinder with an actual
cut in accordance with predetermined setup parameters,
said error correction system comprising:
5   determining means for determining an error
value corresponding to the difference between the
predetermined setup parameters and a measurement of the
actual dimensions of a portion of an engraved area on
said cylinder; and
10   a system coupled to said determining means for
receiving said error value and also for adjusting said
engraver to engrave said actual cut in accordance with
said predetermined setup parameters.

21.   The error correction system as recited in claim
20 wherein said determining means comprises:
        a strobe for strobing said portion of said
engraved area and generating a frame of data in response

5   thereto;
        a processor coupled to said strobing system for
receiving said frame of data and also for generating said
error value.

22.   The error correction system as recited in claim
21 wherein said processor comprises:
        means for generating a plurality of sectors of
data corresponding to said frame of data, for using said

5   plurality of density levels to determine a minimum and
maximum density range for each sector from which
black/white and white/black thresholds can be determined
and also for using said transitions to calculate the
actual dimensions of a cell within said portion of said

10   engraved area.

23.   The error correction system as recited in claim
22 wherein said strobe further comprises an automatic
focusing system.

24.   The error correction system as recited in claim
21 wherein said processor comprises a program; said
program being capable of generating a plurality of
histograms of data corresponding to said frame of data,

5   for using said plurality of level extremes of data to
determine a plurality of transition points corresponding
to black/white and white/black transitions within said
histograms, and also for using said transition points to
calculate the actual dimensions of a cell within said

10   portion of said engraved area.

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25.   The error correction system as recited in claim
20 wherein said actual cut is a cell having any
predetermined size.

26.   The error correction system as recited in claim
21 wherein said system further comprises:
           an engraving head;
           a first driver for coupling a stylus to said
5   engraving head and for causing said stylus to move
       towards and away from said cylinder;
           a second driver coupled to said engraving head
       for driving the engraving head across said cylinder;
           a third driver coupled to said cylinder for
10   rotatably driving said cylinder;
           a computer coupled to said processor and said
       first, second and third drivers; said computer being
       capable of receiving a plurality of input signals
       corresponding to said predetermined setup parameters and
15   also for generating a plurality of energizing signals for
       energizing said first, second, and third drivers to cause
       said engraver to engrave said actual cut having
       dimensions corresponding to said predetermined setup
       parameters, said computer also being capable of receiving
20   said error value and adjusting said energizing signals
       such that said engraver engraves an actual cut
       corresponding to said predetermined setup parameters.

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27.   A engraver for engraving a cylinder with an
actual cut in accordance with predetermined setup
parameters, said engraving apparatus comprising:
           a cylinder rotatably mounted on a rotary
5   support;
           an engraving head operatively related to said
cylinder;
           a stylus associated with said engraving head;
           a first driver for causing said stylus to move
10   towards and away from said cylinder;
           a second driver coupled to said engraving head
for driving the engraving head radially across said
cylinder;
           a third driver coupled to said cylinder for
15   rotatably driving said cylinder; and
           a computer coupled to said processor and said
first, second and third drivers; said computer being
capable of receiving a plurality of input signals
corresponding to said predetermined setup parameters and
20   also for generating a plurality of energizing signals for
energizing said first, second, and third drivers to cause
said engraver to engrave said actual cut having
dimensions corresponding to said predetermined setup
parameters;
25   an error detector comprising:
           determining means for determining an error
value corresponding to the difference between said
predetermined setup parameters and a measurement of the
actual dimensions of a portion of an engraved area on
30   said cylinder; and
           said computer also being capable of receiving
said error value and adjusting said plurality of
energizing signals such that said engraver engraves an
actual cut corresponding to said predetermined setup
35   parameters.

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28.   The engraver as recited in claim 27 wherein
said determining means comprises:

        a strobe for strobing said portion of said
engraved area and generating a frame of data in response
thereto;

        a processing system coupled to said strobe for
receiving said frame of data and also for generating said
error value.

29.   The engraver as recited in claim 28 wherein
said processor comprises an automatic focusing system.

30.   The engraver as recited in claim 28 wherein
said strobe further comprises an automatic focusing
system.

31.   The engraver as recited in claim 28 wherein
said processor comprises a program; said program being
capable of generating a plurality of histograms of data
corresponding to said frame of data, for using said
plurality of histograms of data to determine a plurality
of transition points corresponding to black/white and
white/black transitions within said histograms, and also
for using said transition points to calculate the actual
dimensions of a cell within said portion of said engraved
area.

32.   The engraver as recited in claim 27 wherein
said actual cut is a cell of any predetermined size.

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33.   An engraving control for use in a gravure
engraver having a stylus driver for driving a stylus
towards and away from a cylinder, comprising:
          input means for generating parameter signals
5   indicating desired dimensions for cavities to be engraved
by the stylus;
          setup means coupled to said error detection
means and responsive to said parameter signals for
generating an AC multiplication signal and a video
10   multiplication signal;
          multiplication means responsive to an AC
multiplication signal and a video multiplication signal
for adjusting the amplitudes of said AC signal and said
video signal prior to application thereof to the stylus
15   driver;
          error detection means for generating an error
signal corresponding to the difference between said
predetermined setup parameters and an actual measurement
of the actual dimensions of a portion of an engraved area
20   on said cylinder; and
          said setup means also being responsive to said
error value so that said AC multiplication signal and
video multiplication signal generally corresponds to the
predetermined setup parameters.

34.   The engraver control as recited in claim 33
wherein said determining means comprises:
          a strobe for strobing said portion of said
engraved area and generating a frame of data in response
5   thereto;
          a processor coupled to said strobing system for
receiving said frame of data and also for generating said
error value.

35.   The engraver control as recited in claim 34
wherein said processor comprises an automatic focusing
system.

36.   The engraver control as recited in claim 34 wherein said strobe further comprises an automatic focusing system.

37.   The engraver control as recited in claim 34 wherein said processor comprises a program; said program being capable of generating a plurality of histograms of data corresponding to said frame of data, for using said plurality of histograms of data to determine a plurality of transition points corresponding to black/white and white/black transitions within said histograms, and also for using said transition points to calculate the actual dimensions of a cell within said portion of said engraved area.

38.   The engraver control as recited in claim 33 wherein said actual cut is a cell having any predetermined size.

39.   Engraver control according to claim 33 wherein said input means comprises means for indicating a desired black cell width, a desired channel width for channels connecting consecutively engraved cells and a desired highlight cell width.

40.   Engraver control according to claim 39 wherein said input means further comprises means for indicating a highlight voltage signal; said setup means comprising means responsive to said highlight voltage signal for generating a white offset signal; and said engraving control means comprising means for supplying said white offset signal to said stylus drive means.

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41.   Engraver control according to claim 39 wherein
said setup means comprises linearizing means for
adjusting said AC multiplication signal and said video
multiplication signal to compensate for nonlinear changes
in engraving requirements.

42.   Engraver control according to claim 41 wherein
said linearizing means comprises means for tabulating
linearizing corrections for said black cell width and the
channel depth corresponding to said channel width, and
means responsive to said correction for performing said
adjusting.

43.   Engraver control according to claim 39 wherein
said setup means comprises means for generating an offset
signal sufficient for maintaining said stylus out of
engraving contact with said cylinder when said video
signal has a predefined value, and means for supplying
said offset signal to said stylus drive means.

44.   Engraver control according to claim 33, said
setup means comprising means responsive to said parameter
signal for generating a white offset signal and said
engraving control means further comprising summing means
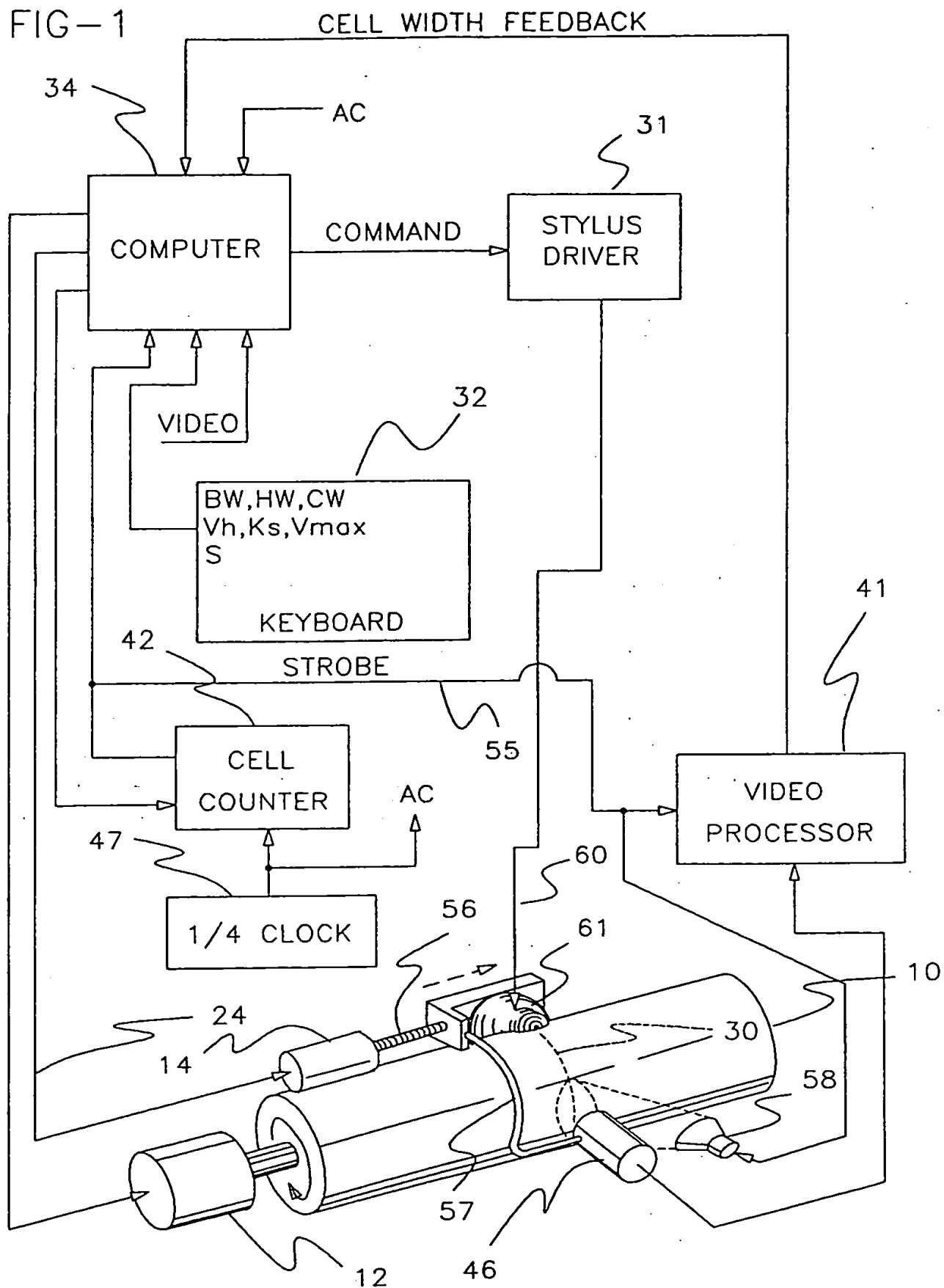for summing said white offset signal and said video
signal.

FIG-1

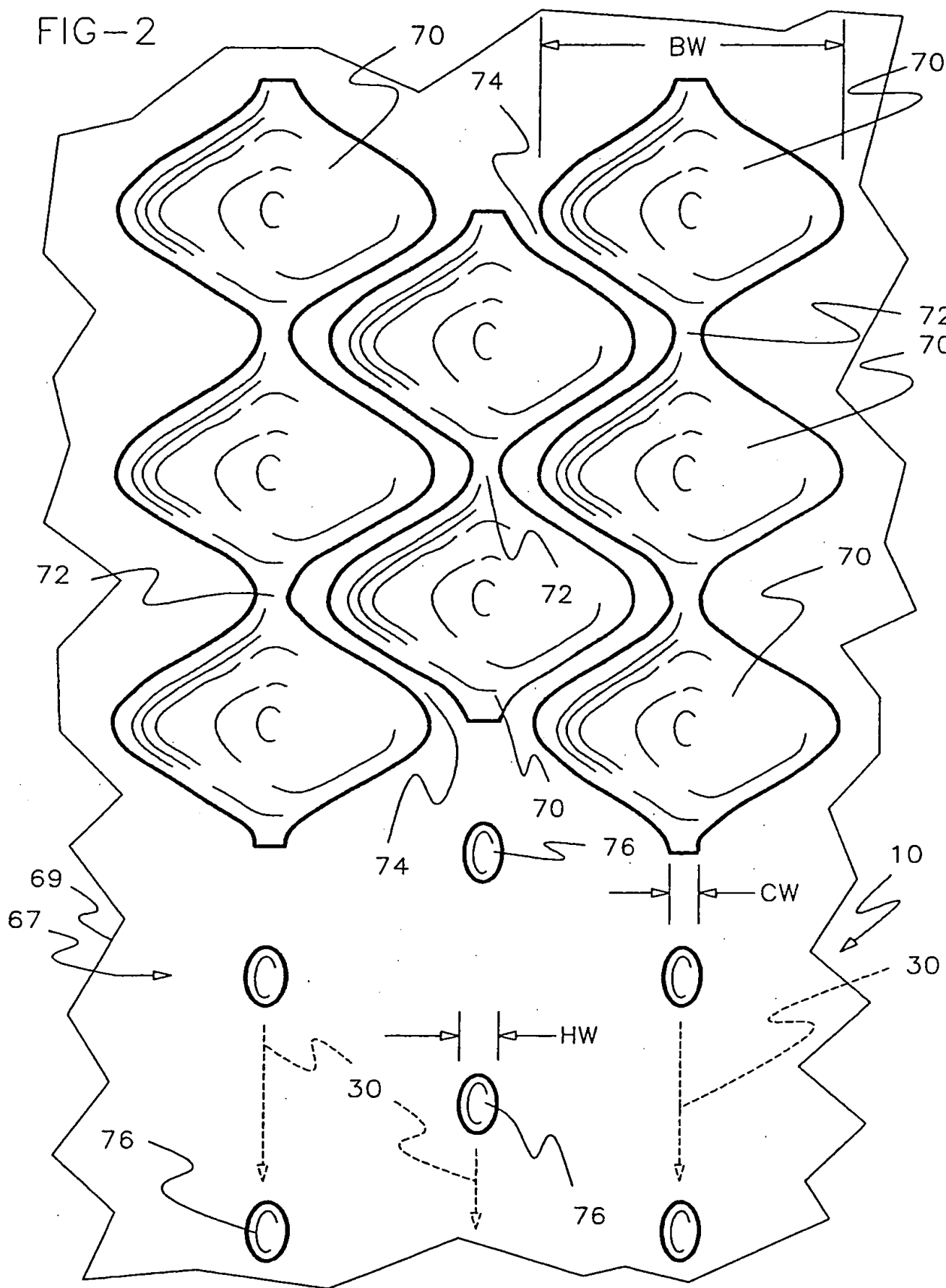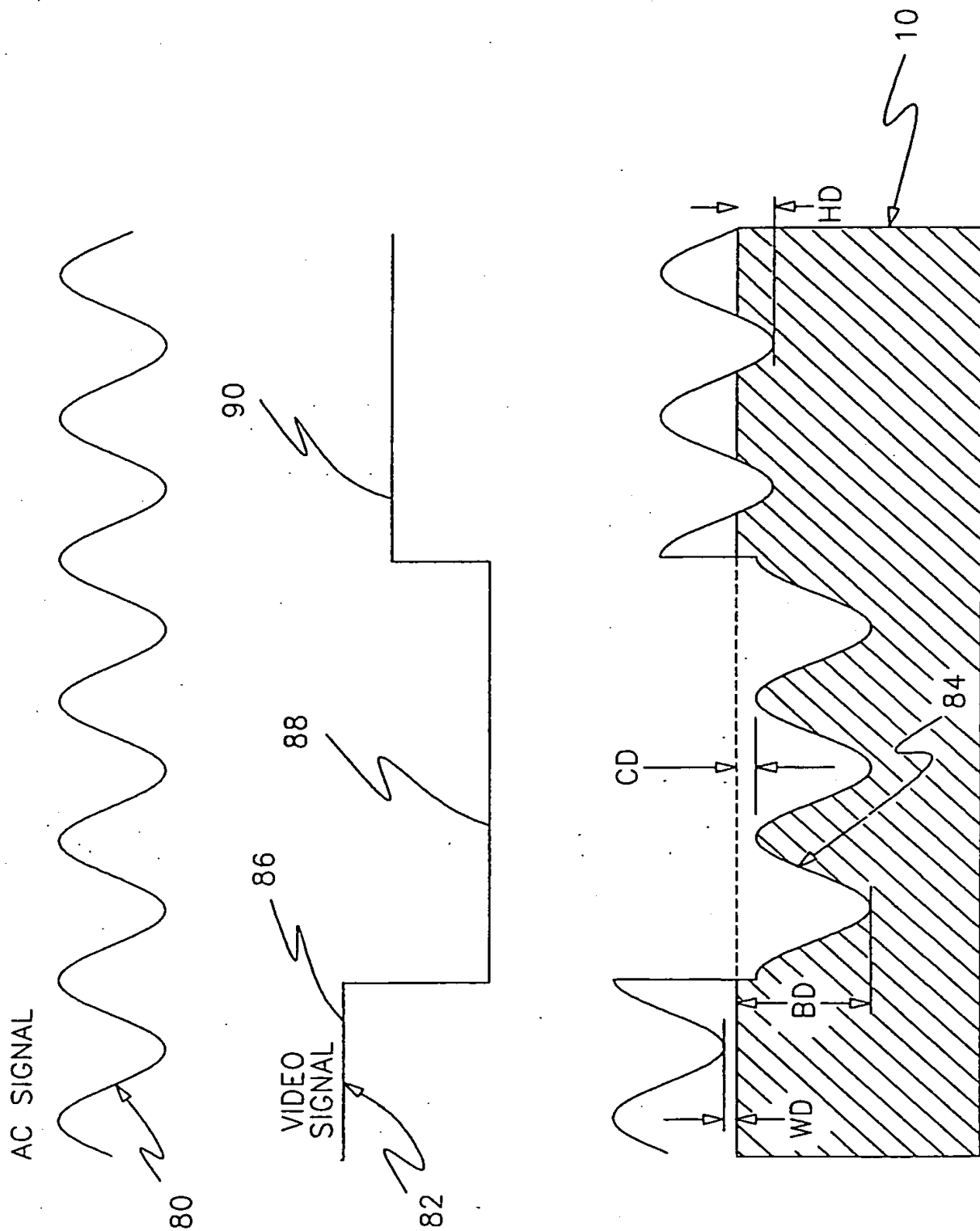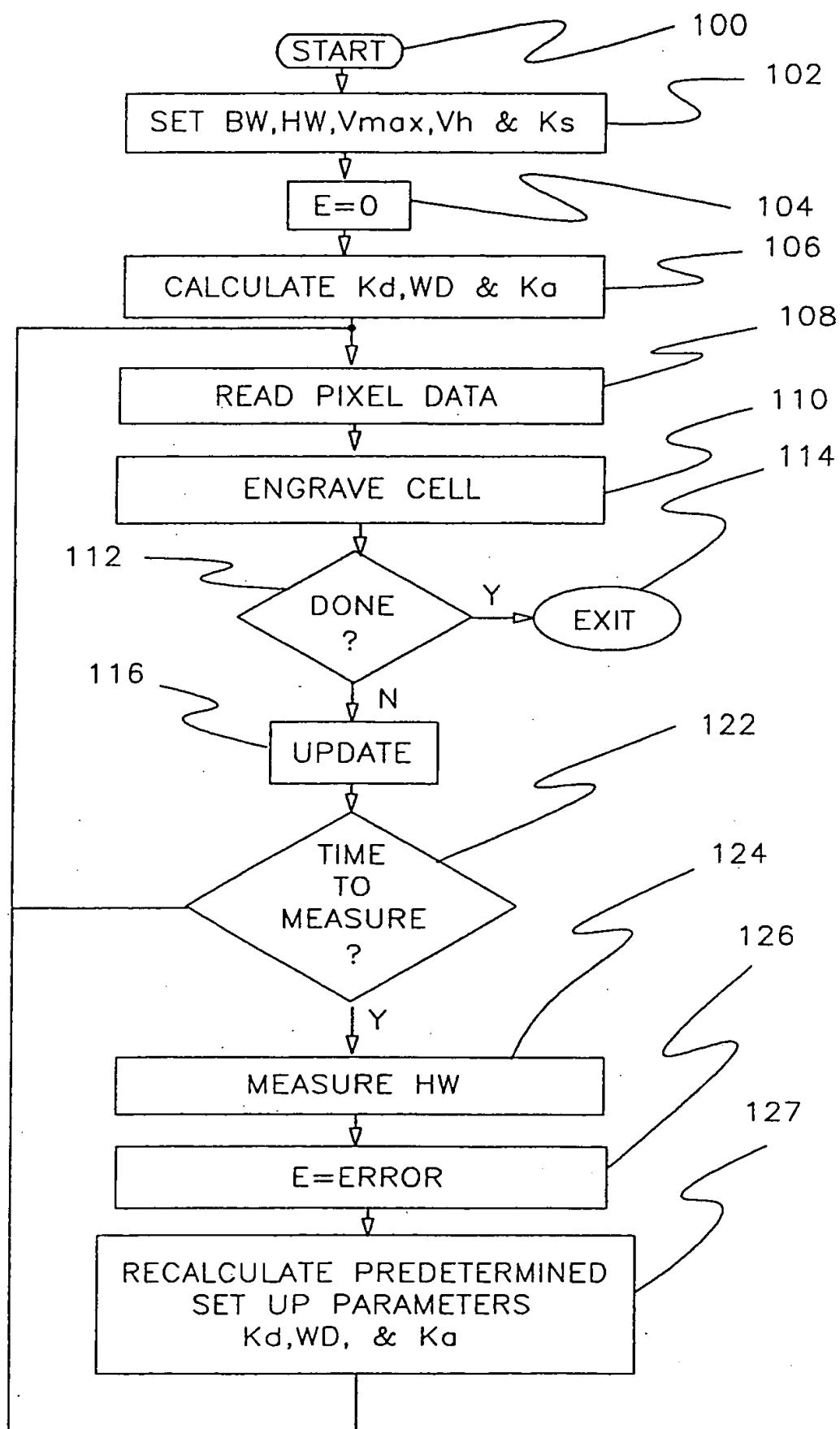CELL WIDTH FEEDBACK

FIG-2

FIG-3

AC SIGNAL

80

VIDEO SIGNAL

82

86

88

90

10

HD

CD

84

BD

WD

FIG-4

```
            ( START )                    ~ 100

        ┌──────────────────────────┐
        │ SET BW,HW,Vmax,Vh & Ks   │    ~ 102
        └──────────────────────────┘

              ┌────────┐
              │  E=0   │               ~ 104
              └────────┘

        ┌──────────────────────────┐
        │ CALCULATE Kd,WD & Ka      │    ~ 106
        └──────────────────────────┘

        ┌──────────────────────────┐
        │ READ PIXEL DATA           │    ~ 108
        └──────────────────────────┘

        ┌──────────────────────────┐    ~ 110
        │ ENGRAVE CELL              │
        └──────────────────────────┘    ~ 114

  112          ╱╲
          ╱──────────╲     Y
         ╱   DONE      ╲───────▶ ( EXIT )
         ╲     ?       ╱
          ╲──────────╱
               │ N
  116     ┌──────────┐
          │  UPDATE  │
          └──────────┘

               │                        ~ 122
              ╱╲
          ╱──────────╲
         ╱    TIME     ╲
         ╲     TO      ╱              ~ 124
         ╱  MEASURE    ╲
         ╲     ?       ╱              ~ 126
          ╲──────────╱
               │ Y

        ┌──────────────────────────┐
        │ MEASURE HW                │
        └──────────────────────────┘    ~ 127

        ┌──────────────────────────┐
        │ E=ERROR                   │
        └──────────────────────────┘

        ┌──────────────────────────────┐
        │ RECALCULATE PREDETERMINED     │
        │ SET UP PARAMETERS             │
        │ Kd,WD, & Ka                   │
        └──────────────────────────────┘
```

FIG−5

FIG-6

FIG-7

START — 136

138

SCAN FRAME

140

142

LAST
LINE
?

Y → EXIT

N

FIND LINE
TRANSITION POINTS — 144

GET WHITE RANGES — 146

148

SPLIT
?

N

152

Y

TAG EACH MEMBER

154

SET FLAG

156

FLAG
SET
?

N

Y

142

158

MERGE
?

Y → EXIT

N

160

SEP.>
PREV. SEP.
?

N

Y

162

164

HW=SEP

INCREMENT LINE NUMBER

FIG−8A

170

172

174

START

SCAN FRAME

THRESHOLD SECTORS

176

USING THRESHOLD
POINTS FIND
TRANSITION POINTS

180

MEMORY FILL IN
OF BLACK CAVITIES

181
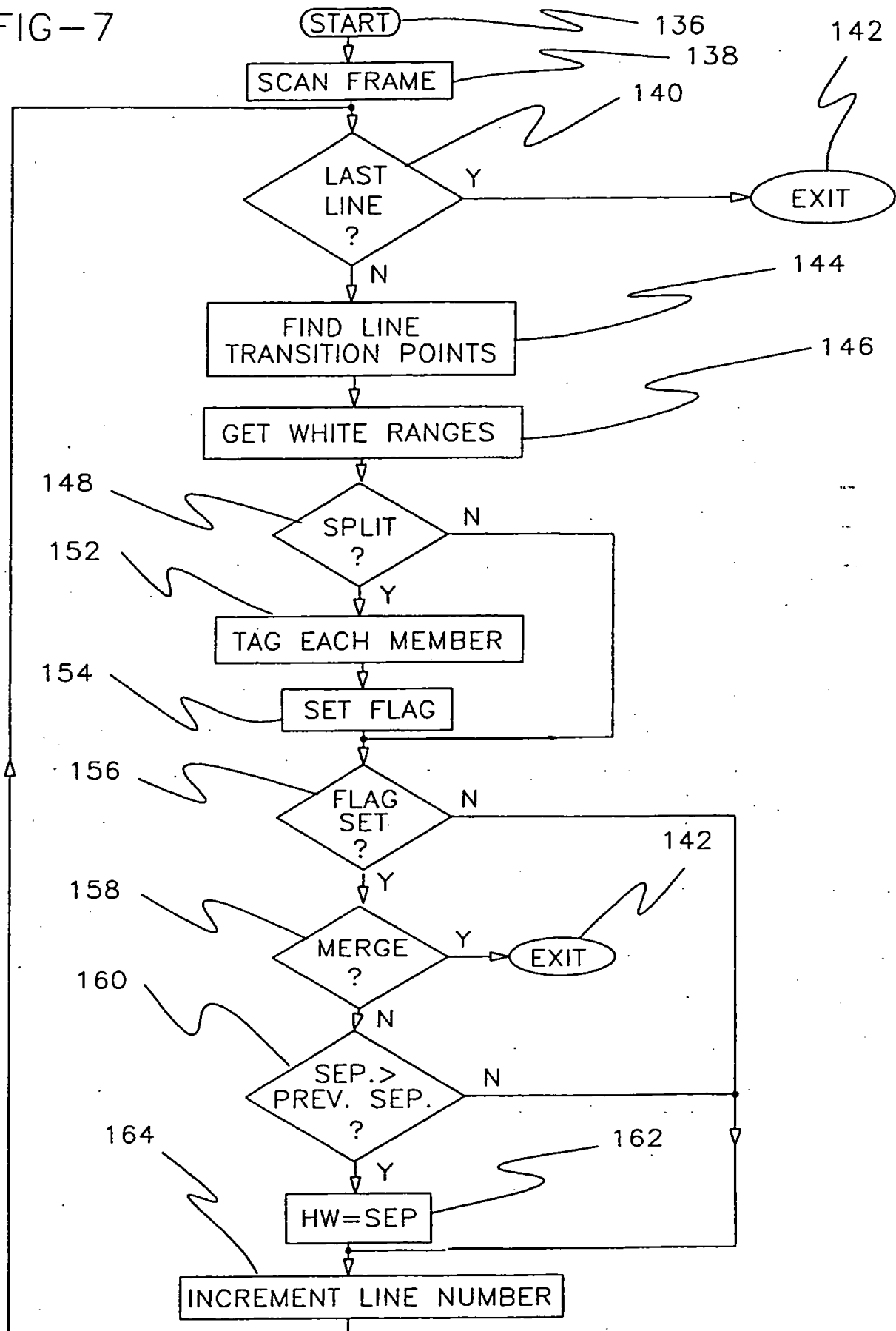
LOCATE BLACK/WHITE
AND WHITE/BLACK
TRANSITIONS
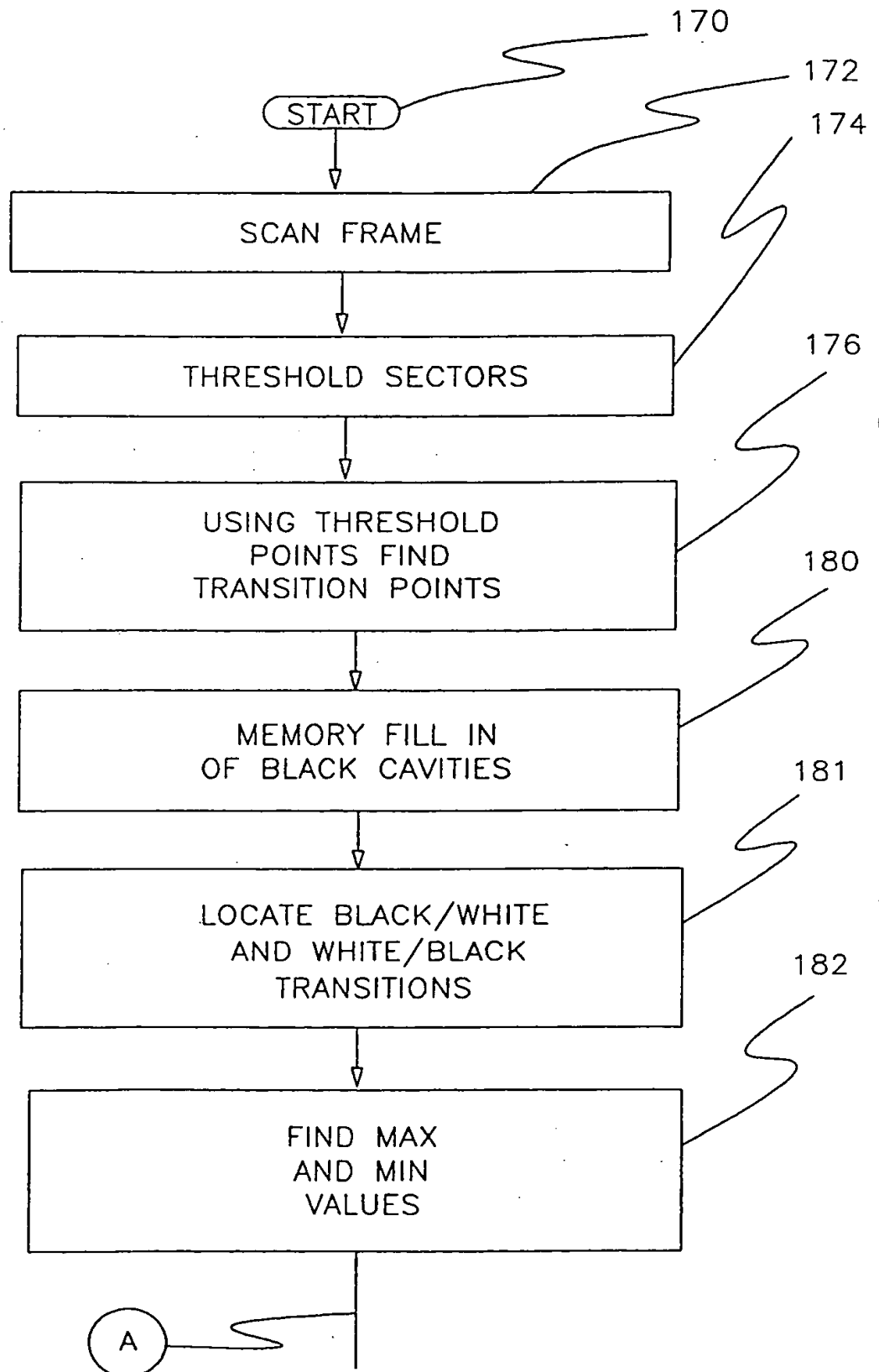
182
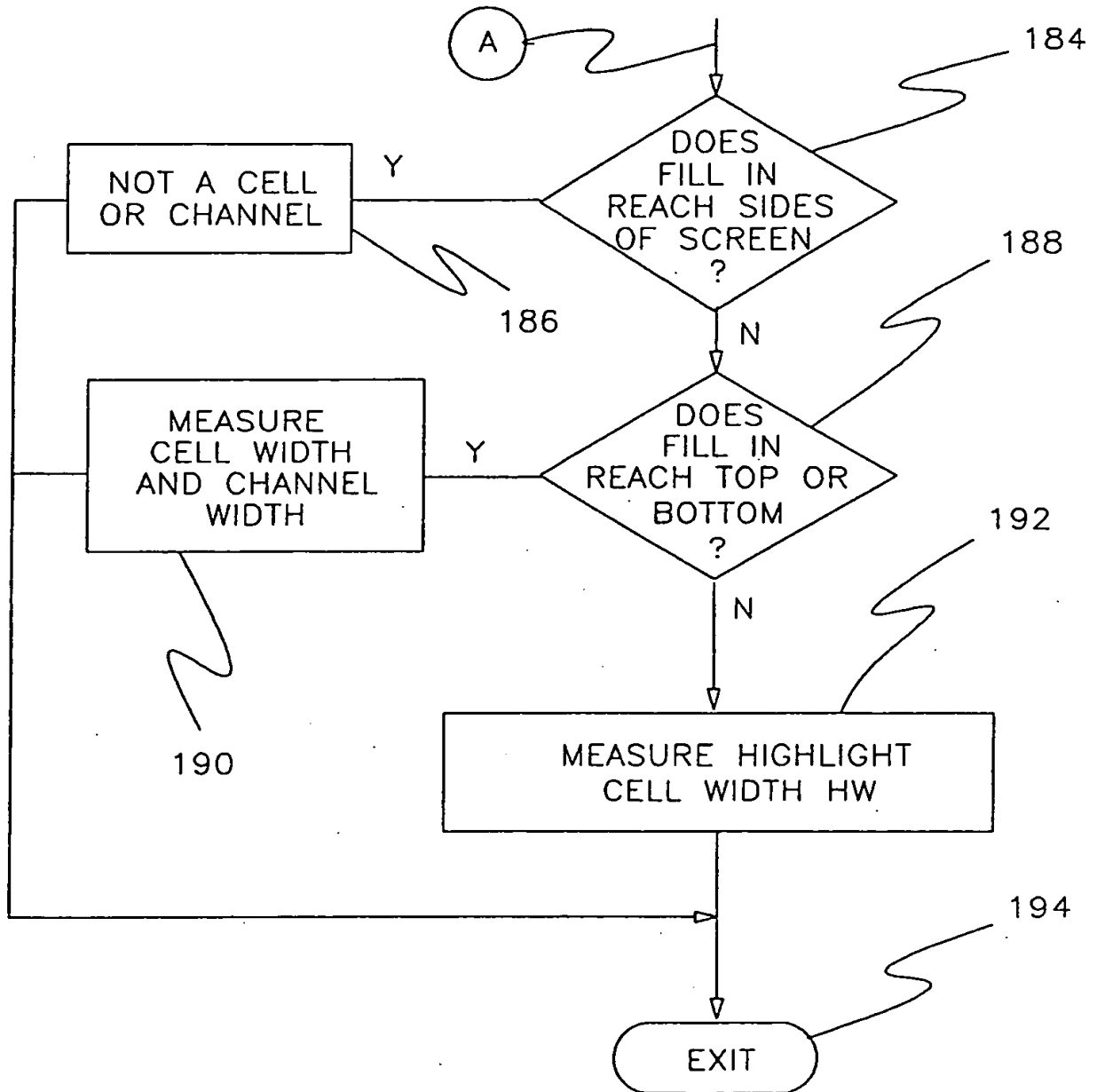
FIND MAX
AND MIN
VALUES

A

FIG−8B

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US94/01871

A.	CLASSIFICATION OF SUBJECT MATTER

IPC(5) :Please See Extra Sheet.
US CL : 358/299; 409/208; 364/474.22, 474.37; 318/638, 640; 356/379

According to International Patent Classification (IPC) or to both national classification and IPC

B.	FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 358/296, 299; 346/1.1; 409/204, 207, 208; 364/474.12, 474.22, 474.26, 474.35, 474.37; 318/638, 640; 356/379

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS, search terms:rotogravure, error, correction, stylus, engraving, gravure, measure, area

C.	DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 3,918,348 (Runft) 11 November 1975, col. 3-4	1-44
Y	US, A, 4,052,739 (Wada et al) 04 October 1977, col. 3-7	3-7, 11-13
A	US, A, 4,451,856 (Buechler) 29 May 1984, entire document	1-44
A	US, A, 4,972,323 (Cauwet) 20 November 1990, entire document	3-7, 11-13
Y	US, A, 4,944,593 (Kalstroem et al) 31 July 1990, fig. 1, col. 1-3	1-44

[X]	Further documents are listed in the continuation of Box C.	[ ]	See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be part of particular relevance		
"E"	earlier document published on or after the international filing date	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed	"&"	document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 May 1994	1 6 JUL 1994

Name and mailing address of the ISA/US	Authorized officer
Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	FRAHM, ERIC
Facsimile No. NOT APPLICABLE	Telephone No. (703) 308-1317

Form PCT/ISA/210 (second sheet)(July 1992)*

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 5,029,011 (Fraser) 02 July 1991, fig. 8 and 9, col. 1-6	33-44
Y,P	US, A, 5,229,861 (Nozaka et al) 20 July 1993, entire document	16, 22, 24, 31, 37
X --,E Y	US, A, 5,293,426 (Wouch et al) 08 March 1994, fig. 1-3, col. 2-6	1, 2, 8-10, 14-32 ------------ 3-7, 11-13, 33-44

A. CLASSIFICATION OF SUBJECT MATTER:
IPC (5):

H04N 1/00, 1/40; B23C 9/00; G06F 15/46; G06G 7/66; G05B 1/06; G01B 11/28